Effect of Sodium Bicarbonate Buccal Infiltration on the Success of Inferior Alveolar Nerve Block in Mandibular First Molars with Symptomatic Irreversible Pulpitis: A Prospective, Randomized Double-blind Study

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Abstract

Introduction: The purpose of this prospective, randomized, double-blind study was to evaluate the effect of a buccal infiltration of sodium bicarbonate on the anesthetic success of the inferior alveolar nerve block (IANB) for mandibular first molars in patients with symptomatic irreversible pulpitis. **Methods:** One hundred patients diagnosed with symptomatic irreversible pulpitis of a mandibular first molar were selected. The patients randomly received a buccal infiltration injection of either 0.7 mL 8.4% sodium bicarbonate with 0.3 mL 2% lidocaine containing 1:80,000 epinephrine or 0.7 mL sterile distilled water with 0.3 mL 2% lidocaine containing 1:80,000 epinephrine in a double-blind manner. After 15 minutes, all the patients received conventional IANB injection using 3.6 mL 2% lidocaine with 1:80,000 epinephrine. Access cavity preparation was initiated 15 minutes after the IANB injection. Lip numbness was a requisite for all the patients. Success was determined as no or mild pain on the basis of Heft-Parker visual analog scale recordings upon access cavity preparation or initial instrumentation. Data were analyzed using the *t*, chi-square and Mann-Whitney *U* tests. **Results:** The success rate after the buccal infiltration of sodium bicarbonate was 78%, whereas without the buccal infiltration of sodium bicarbonate it was 44% ($P < .001$). **Conclusions:** A buccal infiltration of 0.7 mL 8.4% sodium bicarbonate increased the success rate of IANBs in mandibular first molars with symptomatic irreversible pulpitis. *(J Endod 2016;42:1458–1461)*

Key Words

Acid-sensing ion channel, inferior alveolar nerve block, irreversible pulpitis, local anesthesia, transient receptor potential vanilloid receptor type 1

Significance

The administration of a buccal infiltration injection of 0.7 mL 8.4% sodium bicarbonate before an inferior alveolar nerve block injection can be helpful for clinicians to improve the efficacy of the anesthesia in mandibular first molars with symptomatic irreversible pulpitis.

The inferior alveolar nerve block (IANB) is the most routine technique used to anesthetize mandibular molars for endodontic treatment (1, 2). However, the success rate is not always adequate to ensure profound pulpal anesthesia, particularly in patients with irreversible pulpitis (3, 4).

The most likely explanation for the decrease in efficacy of local anesthesia in inflamed pulp can be the activation effect of inflammation on the peripheral free terminals of nociceptive neurons and associated central mechanisms (5–9). During inflammation, protons (hydrogen ions) are among the first mediators released by damaged cells, inducing a local pH fall (10, 11). The lowering pH plays a dominant role in the inflammatory activation and sensitization of nociceptive neurons (11–13). This is caused by activation of different ionic channels such as acid-sensing ion channels (ASICs) (11), transient receptor potential channels (8, 11), and tetrodotoxin-resistant sodium channels (14) (Fig. 1). Therefore, it is hypothesized that buccal infiltration of an alkalizing agent will reduce nociceptor activation by increasing the pH of the inflamed tissue and will result in improved efficacy of local anesthesia in patients with symptomatic irreversible pulpitis.

Sodium bicarbonate is an alkalinizing agent that is commonly used for the treatment of metabolic acidosis. It also has been used for buffering of local anesthetics. Some studies have shown that increasing the pH of a local anesthetic solution by adding sodium bicarbonate reduces the pain of injection (15–18), accelerates the onset of anesthesia (15, 17, 18), and improves the efficacy of anesthesia (18–20). Others have reported that adding sodium bicarbonate to local anesthetic solutions cannot reduce the pain of injection (21–23), accelerate the onset of anesthesia (22, 23), or

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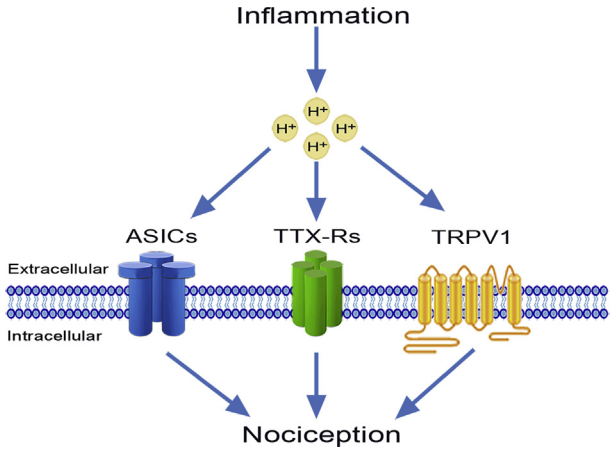

Figure 1. The activation effect of acidic extracellular pH on the ion channel receptors. ASICs, acid-sensing ion channels; TRPV1, transient receptor potential vanilloid 1 channel; TTX-Rs, tetrodotoxin-resistant sodium channels.

improve the efficacy of anesthesia (23, 24). Two recent studies have reported that adding sodium bicarbonate to lidocaine cannot improve the efficacy of IANBs in patients with irreversible pulpitis (25, 26).

There are no studies on the use of buccal infiltration injection of an alkalizing agent for IANBs in teeth with irreversible pulpitis. The purpose of this prospective, randomized, double-blind study was to evaluate the effect of a buccal infiltration injection of 0.7 mL 8.4% sodium bicarbonate on the success rate of IANBs for mandibular first molars in patients with symptomatic irreversible pulpitis.

Materials and Methods

One hundred healthy adult patients participated in this study. They were emergency patients of the clinic of the endodontic department of Isfahan University of Medical Sciences, Isfahan, Iran. We excluded potential patients who were under 18 years of age, had a history of significant medical conditions, were pregnant, were allergic to local anesthetics or sulfites, were taking any medications that might influence anesthetic assessment, had active sites of pathosis in the area of injection, and were unable to give informed consent. The ethics committee of the university approved the protocol of the study (no. 3941020, ClinicalTrials.gov number, NCT02726737). Written informed consent was obtained from all the patients. To qualify for inclusion in the study, each patient had a vital mandibular first molar with active moderate to severe pain and had a prolonged response to cold testing with cold spray (Endo-Frost; Coltène-Whaledent, Langenau, Germany). Patients with no response to cold testing, no vital coronal pulp tissue on access, or a periapical lesion (other than widening of the periodontal ligament space) were not included in the study. Therefore, each patient had a vital mandibular first molar with a clinical diagnosis of symptomatic irreversible pulpitis.

Each patient rated his or her initial pain on a Heft-Parker visual analog scale (HP-VAS) (27). This scale is a 170-mm marked line that is divided into 4 categories with various terms describing the level of pain. No pain, mild pain, moderate pain, and severe pain were indicated by 0 mm, 1- to 54-mm, 55- to 113- mm, and 114- to 170-mm divisions, respectively. Patients exhibiting moderate to severe initial pain were included in the study.

For the sodium bicarbonate group, 0.7 mL 8.4% sodium bicarbonate (Caspian Tamin Pharmaceutical Co, Rasht, Iran) was drawn with a sterile microliter syringe (Hamilton, Bonaduz, Switzerland) fitted with a disposable 27-G needle. Then, 0.3 mL 2% lidocaine with 1:80,000 epinephrine (Lignospan; Septodont, Saint Maur des Fosses, France) was drawn with the same syringe. Therefore, the sodium bicarbonate solution contained 0.7 mL 8.4% sodium bicarbonate and 0.3 mL 2% lidocaine. The syringe was inverted 5 times to mix the solution, and no precipitation was observed. For the non–sodium bicarbonate group, 0.7 mL sterile distilled water was drawn with the Hamilton syringe. Then, 0.3 mL 2% lidocaine with 1:80,000 epinephrine was added in the same way. Therefore, the non–sodium bicarbonate solution contained 0.7 mL sterile distilled water and 0.3 mL 2% lidocaine. A trained dental assistant prepared the solutions just before the injections and coded them in a random manner. One operator administered buccal infiltration injections of either sodium bicarbonate or non–sodium bicarbonate solution for each patient. The operator and patients were both blinded to the contents of the solution.

Before each buccal infiltration, the mucosa was dried, and 20% benzocaine gel (Ultradent Products Inc, South Jordan, UT) was applied to the injection site for 60 seconds. The intended target site was centered over the buccal root apices of the mandibular first molar to be treated. The 27-G needle was placed into the alveolar mucosa and advanced until the needle was estimated to be at or just superior to the apices of the tooth. The solution was deposited over a period of 1 minute.

After 15 minutes, the same operator administered 2 standard IANBs (1.8-mL cartridges) of 2% lidocaine with 1:80,000 epinephrine (Lignospan; Septodont, Saint Maur des Fosses, France) for each patient. All the injections were performed using a standard aspirating dental injection syringe and a 27-G, 31-mm needle (CK ject; CK Dental, Kor-Kyungji-do, Korea). Lip numbness was considered as a criterion for IANB achievement; the patient was questioned for lip numbness 15 minutes after the injection. If lip numbness was not achieved, the IANB was indicated as missed, and the patient was excluded from the study. No patient was excluded from the study as a result of a lack of lip numbness. Fifteen minutes after the injection, the teeth were isolated with a rubber dam, and access cavities were prepared.

The same operator instructed the patients to rate any pain felt during access cavity preparation or the initial file placement. If the patient felt pain, the treatment was immediately ceased, and the patient rated the pain level by using the HP-VAS. The success of the IANB was defined as no pain or mild pain (HP-VAS score $\leq$54).

Statistical Analysis

Data on age, sex, initial pain, and the success of IANB ratings were statistically analyzed using SPSS software version 20 (IBM Corporation, Armonk, NY). Comparisons between the sodium bicarbonate and non–sodium bicarbonate groups for the success of the IANB and sex differences were analyzed using the chi-square test, age was analyzed using the t test, and initial pain was analyzed using the Mann-Whitney U test. With a 2-sided alpha risk of 0.05, a sample size of 50 subjects per group was required to detect a difference of $\pm$30 percentage points in anesthetic success with a power of more than 0.80. Statistical significance was defined as $P < .05$.

Results

One hundred adult patients, 27 men and 73 women, with an age range of 18–53 years and a mean of 29 $\pm$ 9 years, participated in the study. Baseline variables for the sodium bicarbonate and non–sodium bicarbonate groups are presented in Table 1. There were no significant differences in age, sex, or initial pain between the 2 groups ($P > .05$). The IANB success rate was 78% for the sodium bicarbonate group and 44% for the non–sodium bicarbonate group. There was a statistically significant difference in success rates between the 2 groups ($P < .001$).

TABLE 1. Baseline Variables for the Sodium Bicarbonate and Non–Sodium Bicarbonate Groups

Variable	Sodium bicarbonate	Non–sodium bicarbonate	*P* value†
Total subjects	50	50	
Age (y)	18–53	18–43	.733
Sex			.822
Female	37	36	
Male	13	14	
Initial pain*	107 (28.6)	113 (30.0)	.352

*Mean (standard deviation).

†There were no significant differences between the 2 groups ($P > .05$).

Discussion

The results of this study indicated that a buccal infiltration of sodium bicarbonate 15 minutes before endodontic treatment significantly improves the efficacy of IANBs for first mandibular molar teeth with symptomatic irreversible pulpitis. Baseline variables of patients (age, sex, and initial pain) were not significantly different between the 2 groups. Therefore, these variables had no effect on the results (Table 1). All the teeth had a long response to cold testing and exhibited vital coronal pulp tissue on access preparation with moderate to severe initial pain, which indicated that the teeth had symptomatic irreversible pulpitis.

In the present study, only mandibular first molars were included because second and third molars have a thicker cortical plate and may prevent the solution from penetrating around the apical foramen. Before the study, to determine the patient's tolerance for a supraperiosteal buccal infiltration of 0.7 mL 8.4% sodium bicarbonate and 0.7 mL sterile distilled water, the first author performed each of the 2 injections twice on himself and reported severe and moderate transient pain after the injection of sodium bicarbonate and sterile distilled water, respectively. To solve this problem, 0.3 mL 2% lidocaine with 1:80,000 epinephrine was added to each infiltration solution. Moreover, a topical anesthetic gel was applied before each injection. In this study, patients had no significant pain after the buccal infiltration injections and also no significant lip numbness before the IANB injections.

In this study, the efficacy of IANB was assessed by measuring the pain level during access cavity preparation and initial instrumentation using HP-VAS, and additional tests with an electric pulp tester were omitted. This was based on the results of Nusstein et al (28) in which an electric pulp tester was used for measuring the pain level for teeth with irreversible pulpitis. They reported that after receiving anesthesia, 42% of patients with a negative response to electric pulp testing still reported pain during treatment and needed supplemental injections.

The evidence suggests that the activation of nociceptors by inflammatory mediators is a major cause for a decrease in the success rate of local anesthesia in patients with irreversible pulpitis (5–9). Some studies used a buccal infiltration injection of ketorolac, a nonsteroidal anti-inflammatory drug (29, 30), or dexamethasone, a steroidal drug (31), to reduce tissue inflammation and nociceptor activation to improve the efficacy of IANB for teeth with irreversible pulpitis. Moreover, there is a strong interaction between inflammatory mediators and tissue acidosis in terms of prevalence and magnitude of nociceptor activation (12, 32). The algogenic effects of tissue acidosis are caused by the depolarization of nociceptive neurons through activation of different ion channels (11). ASICs are membrane protein complexes with 6 subunits (33). Some of them are able to be activated by very small acidification from a physiological pH of 7.4 to 7.2 and generate a sustained depolarizing current (11). Among transient receptor potential channels, the role of transient receptor potential vanilloid receptor type 1 (TRPV1) channels is more prominent, and they are expressed predominantly by nociceptors. TRPV1 responds to a pH value below 6. However, mild acidosis in the pH range of 6 to 7 can sensitize the channel to other stimuli such as capsaicin and heat (6, 8, 33). Tetrodotoxin-resistant sodium channels Nav 1.8 and Nav 1.9 are also influenced by tissue acidosis. Local acidosis (weak acid $\geq$ pH = 6.0) prepares them to be suitable for the repetitive activation even at depolarized membrane potentials (14). Furthermore, in relation to the role of acid signaling in pain associated with the trigeminal sensory system, evidence has shown that ASIC3 and TRPV1 are expressed in trigeminal ganglia (10, 34, 35). Therefore, tissue acidosis might have a role in the failure of IANB anesthesia in patients with irreversible pulpitis. Further studies on this issue are desirable.

In conclusion, a buccal infiltration of 0.7 mL 8.4% sodium bicarbonate improved the efficacy of IANB for mandibular first molars in patients with symptomatic irreversible pulpitis.

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The authors deny any conflicts of interest related to this study.

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